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THE FOSSIL VERTEBRATE FAUNA OF STRONGS' CAVE, BORANUP, WESTERN AUSTRALIA

By D. L. COOK, Carpentaria Exploration Company, Brisbane.

INTRODUCTION

Fossilised remains of vertebrates have been known from caves in the coastal limestone of Western Australia for many years. This fauna is most extensively known from the caves of the Margaret River area (Glauert, 1910a, 1910b, 1912a, 1914, 1921b, 1948).

In July 1960 R. M. Howlett collected tooth fragments of *Nototherium* in Strongs' Cave, Boranup (Ar. 8)*, lat. 34° 09′ S, long. 115° 04′ E, which is approximately 30 chains on a bearing of 254° from the old Boranup Mill, burnt out in March 1961, and approximately 4.5 miles north of Karridale (Fig. 1).

Later the present author and others collected numerous teeth and bone fragments from this cave which suggest that the fossils represent a fauna similar to that recorded by Glauert (1910a, 1912a, 1914) from the Mammoth Cave.

This paper reports on what has been discovered and interprets the findings.

MATERIAL AND METHODS

1. Mode of occurrence: The material was collected from the bed of a south-west flowing stream, downstream from a mound of talus which partly fills the entrance chamber of the cave.

Teeth in the majority of cases have been found as enamel only. Some specimens still have a little of the dentine on the inside of the enamel, others are almost complete crowns, and rare specimens are almost complete.

The bone is fragmentary and extensively corroded in most cases. Only in rare cases is a specimen sufficiently complete for identification.

2. Two methods of collection have been used:

a. Quantities of material were collected from the bed of the stream and sieved using a flywire screen. Samples were taken at intervals downstream and upstream from the entrance chamber to determine the extent of the fossil material. The spoil resulting from the sieving was taken to the surface and sorted under the better lighting conditions.

* Western Australian Speleological Group reference, recorded in reports by this group and held by the Battye Library, Perth.

b. By walking upstream and examining the stream bed for tooth enamel which showed up white against the darker sedimentary particles.

Identifications were made using comparative material in the Western Australian Museum and the author's collections.

RESULTS

Descriptions and identifications of the material collected are given. All the material collected has been included, except the completely unidentifiable bone fragments and some fragments of enamel. Table I summarises this information.

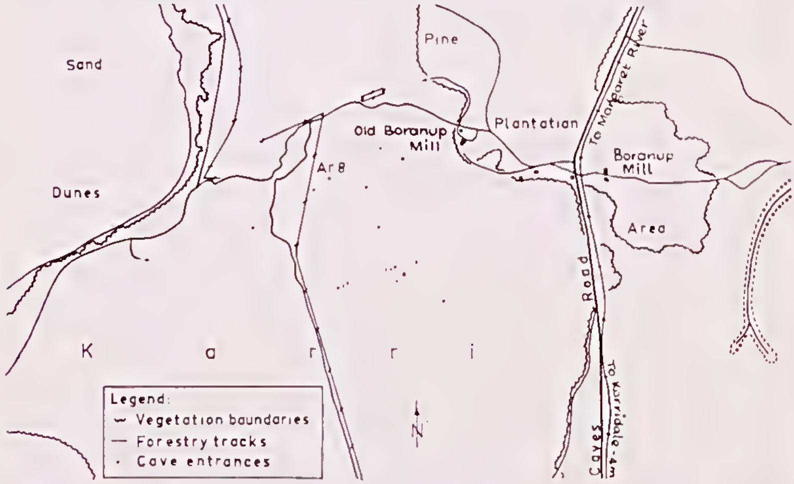

Fig. 1.—Locality map of the area west of the Boranup Mill, Karridale area, Western Australia, showing the position of Strongs' Cave (Ar. 8). Scale, 1 in. = 45 chains.

CHONDRICHTHYES

SELACHII

CARCHARODONTIDAE

Carcharodon sp.

Two shark's teeth were found. The larger (W.A.M. 61.11.1*), the broken off tip of an immature tooth from the right side of the upper jaw, agreed very well with that of *Carcharodon albimors* Whitley. Mr. Gilbert P. Whitley, Australian Museum, Sydney, later confirmed the generic placing but considered that further identification of the specimen was not justified. The second, well-worn tooth was not identified.

REPTILIA

SQUAMATA

SCINCIDAE

Trachysaurus rugosus Gray, 1827

The species is represented by an almost complete right maxilla (W.A.M. 61.11.44). The element is identical in all important features to that of a sub-adult *T. rugosus*.

Numerous ossicles compare well with those of scincids.

* Western Australian Museum catalogue number.

MAMMALIA

CHIROPTERA

VESPERTILIONIDAE

Nyctophilus timoriensis Geoffroy, 1806

A right mandibular ramus with M_2 only, agrees in size, shape and dental characters with comparative material of this species. The specimen is in the author's collection.

RODENTIA

MURIDAE

Rattus sp.

The root formulae and large coronoid spines of three right mandibular rami agree with this genus. The specimens are in the author's collection.

One left and one right lower incisor (both W.A.M. 61.11.45), and three lower right and one upper left incisor (the author's collection) are also murids.

MARSUPIALIA

THYLACINIDAE

Thylacinus cynocephalus Harris, 1808

This species is represented by the crown of a left M_4 (in the author's collection) and a third premolar (W.A.M. 61.11.47) which is almost certainly the lower right.

The molar is the largest of 12 fossil M_4 teeth measured from Western Australia and is therefore thought to have come from a male.

The premolar is amongst the smallest of 16 fossil P_3 teeth measured from Western Australia and is therefore thought to have come from a female.

DASYURIDAE

? Antechinus sp.

A right M_1 of a small dasyurid. Of the four species of small dasyurids which could occur in the area (*Antechinus flavipes, Sminthopsis murina, Phascogale tapoatafa* and *Parantechinus apicalis*) the specimen agrees in size with the first-named—unless it is of an unknown form.

Sarcophilus harrisii Boitard, 1841

The crown of a lower right canine has been compared with the corresponding tooth in *Sarcophilus harrisii, Thylacinus, Canis familiaris dingo* Blumenbach, 1780, and *Vulpes vulpes* Linnaeus, 1758.

The fossil tooth has a poorly developed carina and is subcircular in section. The dingo canine is more oval in section and tends to have a more distinct carina. *Thylacinus* has no carina and is more oval in section. In *Vulpes vulpes* this tooth is more oval in section. The tooth in *Sarcophilus harrisii* agrees in both characters with the fossil tooth.

PHALANGERIDAE

Cercaertus concinna Gould, 1845

One left mandibular ramus without teeth (W.A.M. 62.3.10) has been compared with modern *C. concinna* and is that species.

DIPROTODONTIDAE

Nototherium mitchelli Owen, 1845

Seven molar crown fragments, one molar and one premolar compared well with that of fragmentary *N. mitchelli* from the Mammoth Cave and an almost complete mandible from the Murchison River, Western Australia. Some of these teeth are in the author's collection and others in that of the W.A. Museum (61.11.19-21). A well-worn M_1 and two unworn and therefore unemerged molars indicate that at least two individuals, an adult and a sub-adult, were present.

MACROPODIDAE

MACROPODINAE

Macropus ocydromus Gould, 1842

Four right and four left I^3s (W.A.M. 61.11.4, 61.11.5, 61.11.71 and the author's collection) are this species.

Numerous molars and incisors and four premolars are *Macropus* and almost certainly this species on the association of the third incisors. The incisors represent at least four individuals. One badly eroded right mandibular ramus is an immature animal with M_1 unerupted. Material in the author's and W.A. Museum collections.

Protemnodon anak Owen, 1874

The following teeth are this species.

1. The anterior loph and cingulum of the crown of a right upper molar, almost certainly either the third or fourth. The fragment shows considerable occlusal wear, suggesting an aged* animal.

2. The antero-lateral part of the crown of an upper right permanent premolar (W.A.M. 61.11.58).

Identification of this material was made by comparison with fossil material from the Wellington Caves in New South Wales and the Mammoth Cave in Western Australia.

Published records of this species from W.A. are from three localities; Hastings' Cave, Jurien Bay (Lundelius, 1960; incorrectly referred to as Drovers' Cave); Quanbun Station, West Kimberley (Glauert, 1921a) and Balladonia, Eucla Division (Glauert, 1912b). There is no published record of this species from the Mammoth Cave. However in the W.A. Museum collection there is a right mandibular ramus and right maxilla of a sub-adult animal, labelled as collected from the Mammoth Cave by L. Glauert.

These two additional records extend the former range of the species into the south-west corner of the State.

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* Aged is applied here to teeth in which occlusal wear has almost completely or completely destroyed major cusps. Individuals with this type of wear are assumed to have had their full complement of teeth and been of late adult age.

Protemnodon irma Jourdan, 1837

Nine molar crowns (all W.A.M. 61.11.56) compared well with modern material of *P. irma* and not with related species.

Protemnodon eugenii Desmarest, 1817

The crowns of two molars (W.A.M. 61.11.8 and 61.11.57) compared well with modern material of *P. eugenii* and not with related species.

Setonix brachyurus Quoy & Gaimard, 1830

This species is represented by the following teeth. Three left and three right P^4's (all in the author's collection). One right P_4 (in the author's collection). 28 crowns of molars and complete molars (W.A.M. 61.11.46 and the author's collection).

Potorous gilberti Gould, 1841

Represented by the following elements. Two fragments of left mandibular rami; one (W.A.M. 61.11.46) a sub-adult with Ms 1 & 2, the other (the author's collection) without teeth. One right ramus of an aged animal with Ms 3 & 4 missing (in the author's collection). Crowns of one left and one right P^4 (in the author's collection).

STHENURINAE

Sthenurus occidentalis Glauert, 1910

Fifteen incomplete teeth (in the author's collection and W.A.M. 61,11.10, 61.11.52; 61.11.53, 61.11.62, 61.11.63, 61.11.64, 61.11.68) have been compared with the type series of *S. occidentalis* in the W.A. Museum. They represent at least four individuals of the species.

PERAMELIDAE

Isoodon obesulus Shaw & Nodder, 1797

Represented by one right molar, either M^2 or M^3 (in the author's collection).

DISCUSSION

In the analysis of the data given in this paper it has been decided to follow the presentation adopted by Ride (1960: 76) in his treatment of a fossil mammalian fauna from the Wombeyan Caves, N.S.W. This seems the most satisfactory model to follow in descriptions of fossil faunas and aids comparison. The material is considered from the standpoint of the provenance of the bones and their mode of deposition, the zoogeographical and palaeoclimatic implications, and the age of the fauna.

Provenance of the Material and its Mode of Deposition

The mammalian and reptilian material has apparently been washed from its original site of deposition in the talus mound and transported along the stream where it is found for some distance in its bed; usually in pockets mixed with other sedimentary particles of similar size and density which have been sorted by the stream.

Transport of the material is further supported by polishing and some slight rounding of tooth enamel and the destruetion of bone and dentine. This destruetion of bone and dentine is almost eertainly predominantly due to chemieal aetion caused by prolonged immersion in running water, rather than abrasion. This is supported by well developed pitting in addition to rounding of bone.

TABLE I—RELATIVE ABUNDANCE OF INDIVIDUALS IN THE MATERIAL COLLECTED FROM THE STREAM BED OF STRONGS' CAVE, WESTERN AUSTRALIA.

Genera and species	Number of specimens	Minimum number of individuals
Carcharodon sp.	1	1
Trachysaurus rugosus	1	1
Nyctophilus timoriensis	1	1
Rattus sp.	3	3
Unidentified Muridae	6	4
Thylacinus cynocephalus	2	2
?Antechinus sp.	1	1
Sarcophilus harrisii	1	1
Cercaertus concinna	1	1
Nototherium mitchelli	9	2
Macropus ocydromus	71	4
Protemnodon anak	2	1
P. irma	9	1
P. eugenii	2	1
Setonix brachyurus	35	3
Potorous gilberti	5	2
Sthenurus occidentalis	15	4
Isoodon obesulus	1	1

As would be expeeted if the above is the ease, a gradation can be seen from eomplete teeth and bone elements at the base of the talus pile to polished and rounded enamel fragments in the downstream seetions.

The entranee to the eave is now effeeted through a narrow opening in the sides of a eollapse dolina made up of limestone boulders whieh were onee the roof of a larger eavern (Fig. 2, seetion AA).

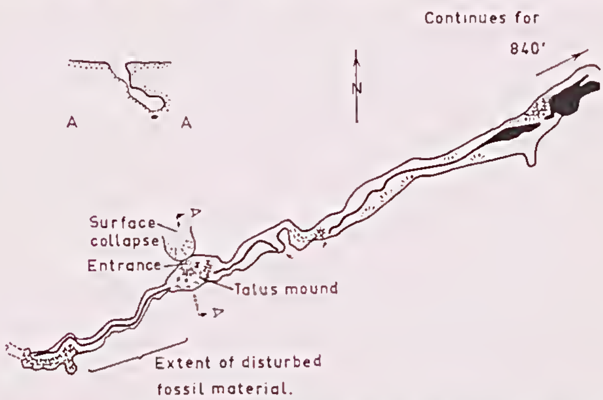

Fig. 2.—Plan and section of Strongs' Cave, Boranup, showing the souree and extent of material deseribed. Seale, 1 in. = 200 ft.

Prior to collapse of the roof there was apparently a wider entrance, no doubt a solution pipe, as these are common in the surrounding limestone and their remains can be seen in the boulders making up the dolina. Through this opening animals have fallen, leaving their remains over the surface of the talus beneath, which was accumulating through the additions of soil washed in and of rock falling from the ceiling. Eventually the cave reached a size where it could no longer support its roof and the resulting collapse sealed off entry to all but the smallest mammals.

For some time it was not known whether the provenance of the shark's teeth was the limestone in which the cave occurs, the talus mound, or a beach deposit* which outcrops in one section of the north-west wall of the downstream section of the cave.

A careful examination of all three provenances was made and shark's teeth were found in the sandy matrix of the beach deposit. These were the broken off tip of a tooth comparable with *Carcharodon,* together with two unidentified fragments of enamel, all polished and well rounded.

Zoogeography and Palaeoclimate

The material derived from the talus can be divided into four groups:—

1. Species which are extinct today, i.e., *Nototherium mitchelli, Protemnodon anak* and *Sthenurus occidentalis.*

2. Species which occurred in historic times but are now almost certainly absent from the area, i.e., *Setonix brachyurus* and *Potorous gilberti.*

3. Species which have existed in historic times in Tasmania, i.e., *Thylacinus cynocephalus* and *Sarcophilus harrisii.*

4. Species known to occur in the area at the present time, i.e., *Trachysaurus rugosus, Nyctophilus timoriensis, Cercaertus concinna, Macropus ocydromus, Protemnodon irma, P. eugenii* and *Isoodon obesulus.*

Certain conclusions are implied from the evidence of these groups.

1. The extinct forms are characteristic of Pleistocene deposits in many parts of Australia. Climatic conditions during this era are considered to have been more humid than at the present (reviewed by Gentilli, 1961).

2. Of those species which occurred in the area in historic times, *Setonix brachyurus* is now confined to small isolated pockets in swamps on the coastal plain of Western Australia as well as being

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* This deposit, which apparently lies at the base of the coastal limestone and on the crystalline basement, is made up of rounded boulders of gneiss (or banded granulite) up to 6 in. across, lying in a matrix of mainly well-rounded quartz grains and shell fragments. Occasional pieces of grey, spongy organic material occur, giving off a faint oily smell. The matrix is unconsolidated except for occasional pieces of flat, elongate limestone which occur in a band of yellowish, unconsolidated sand approximately ¼ in. thick. It is very similar in constituency to the Cowaramup Conglomerate, the basal member of the coastal limestone which rests unconformably on Pre-cambrian gneisses (or banded granulites) in the form of a beach plaster and outcrops on the coast (Kay, 1958). It is thought to be an older deposit than that outcropping on the coast, having formed when the sea-level was higher and the coastline was further east than now.

common on Rottnest and Bald Islands. *Potorous gilberti* is thought to be extinct, and was last collected by Gilbert in 1840 near Albany.

White (1952) has discussed the great decline of *S. brachyurus* on the mainland in the 1930s. That both species were common in comparatively recent times is further supported by the large quantity of remains found as superficial deposits in many of the caves in the south-west of the State. The reason for this apparent sudden decline is not clear, but may be due to the effects of European colonization, climatic change, disease or combinations of these. The effects of colonization have no doubt assisted faunal changes but in the case of *S. brachyurus* are not likely to have caused such a radical change in a short period, over 100 years after colonization began.

Rainfall fluctuations, not necessarily significant, have been noted by Gentilli (1951) in south-west Western Australia since records began in 1877; notably a decreasing summer rainfall with increasing winter rainfall. Again while such a change could be expected to initiate faunal changes, it has been small and gradual and a similar small and gradual faunal change would be expected.

The sudden effects of a fatal epidemic disease would seem to be a more likely cause for such a change in population levels.

No conclusions as to past climate are therefore warranted on the evidence of these two species.

3. The occurrence of *Sarcophilus harrisii* and *Thylacinus cynocephalus* may act as a climatic indicator. Both species occur today only in Tasmania, an area of high humidity which suggests itself as a necessary factor for their persistence. However, the possibility of other factors such as disease and competition with the Dingo must not be overlooked.

The fact that both species occur today in Tasmania seems to furnish further evidence that high humidity is a necessary factor for their existence.

The Age of the Fauna

An absolute age determination of this deposit has not been attempted for two reasons:—

1. There is insufficient collected skeletal material for a determination. If available, the material would not necessarily be contemporary and in most cases could not afford to be destroyed.

2. Because the material is not *in situ*, contemporary charcoal cannot be used instead.

A C14 date will only be warranted if and when a detailed excavation of the deposit in the talus mound is carried out.

A useful comparison can be made between this fauna and that from the nearby Mammoth Cave (see Table II) which has been dated at its upper level at greater than 37,000 B.P. (Lundelius, 1960) and is therefore at least as old as Upper Pleistocene.

Six of the nine extinct forms from Mammoth Cave have not yet been found in Strongs' Cave, which suggests that they may have already become extinct and the deposit therefore represents a more recent time. However, it seems from an examination of the W.A.

Museum material from Mammoth Cave that all six species were poorly represented and their absence so far from Strongs' Cave may purely be a reflection of low sampling there.

TABLE II—FAUNAL LIST FROM MAMMOTH CAVE BASED ON LUNDELIUS (1960) WITH MODIFICATIONS AND AN ADDITION BY THE PRESENT AUTHOR.

*Phascolomys hacketti Glauert
*P. parvus (Owen)
*Nototherium mitchelli Owen
†Phascolarctos cinereus (Goldfuss)
*Thylacoleo carnifex Owen
*Macropus magister (De Vis)
M. cangaru (Muller) (= M. ocydromus Gould, in this paper)
*Zaglossus hacketti Glauert
*Sthenurus occidentalis Glauert
†Sarcophilus harrisii (Boitard)
†Thylacinus cynocephalus (Harris)
Protemnodon irma (Jourdan)
*P. anak Owen
Setonix brachyurus (Quoy & Gaimard)
Trichosurus vulpecula (Kerr)
Pseudocheirus occidentalis (Thomas)
*Potorous gilberti (Gould)
Phascogale tapaotafa (Meyer)
Dasyurus geoffroyi (Gould)
Isoodon obesulus (Shaw & Nodder)
Macrotis lagotis (Reid)
Tachyglossus aculeatus (Shaw)
*Palorchestes sp.
Sminthopsis sp.
Rattus fuscipes (Waterhouse)

The conclusion then is that comparison of the Strongs' Cave fauna with the Mammoth Cave fauna and recent faunas, together with palaeoclimatic considerations, suggests that the deposit is Pleistocene in age. A slender argument can be brought forward that it is later than the Mammoth Cave fauna and extends in age to Recent or sub-modern times.

General Considerations

Pits such as the one into which the fauna of Strongs' Cave must have fallen before the final roof collapse, may be very efficient mechanisms for the sampling of past faunas. If this is the case very significant population studies could be made of past successive faunas. Unfortunately, at present it is impossible to determine with certainty the success of such a mechanism; the different habits of the species would seem to be enough in themselves to bring about variations in the sampling which are not a true reflection of the actual fauna.

Variation within a species may be well represented providing that individuals of the same age are used. Relative-age population studies will probably be unreliable due to the differing habits of individuals of different age within a single species and the tendency for poor preservation of juvenile elements. Both these factors will establish a sampling bias.

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*Extinct.
†Extinct in W.A.

The sample deseribed in this paper should not therefore be treated as a true representation of the surfaee fauna during the period of deposition.

Further detailed study of this deposit in the region of the talus mound will no doubt result in a larger and more eomplete sample on whieh to base population studies.

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